Systems Thinking Assessment
of
MD Teams External Dynamics

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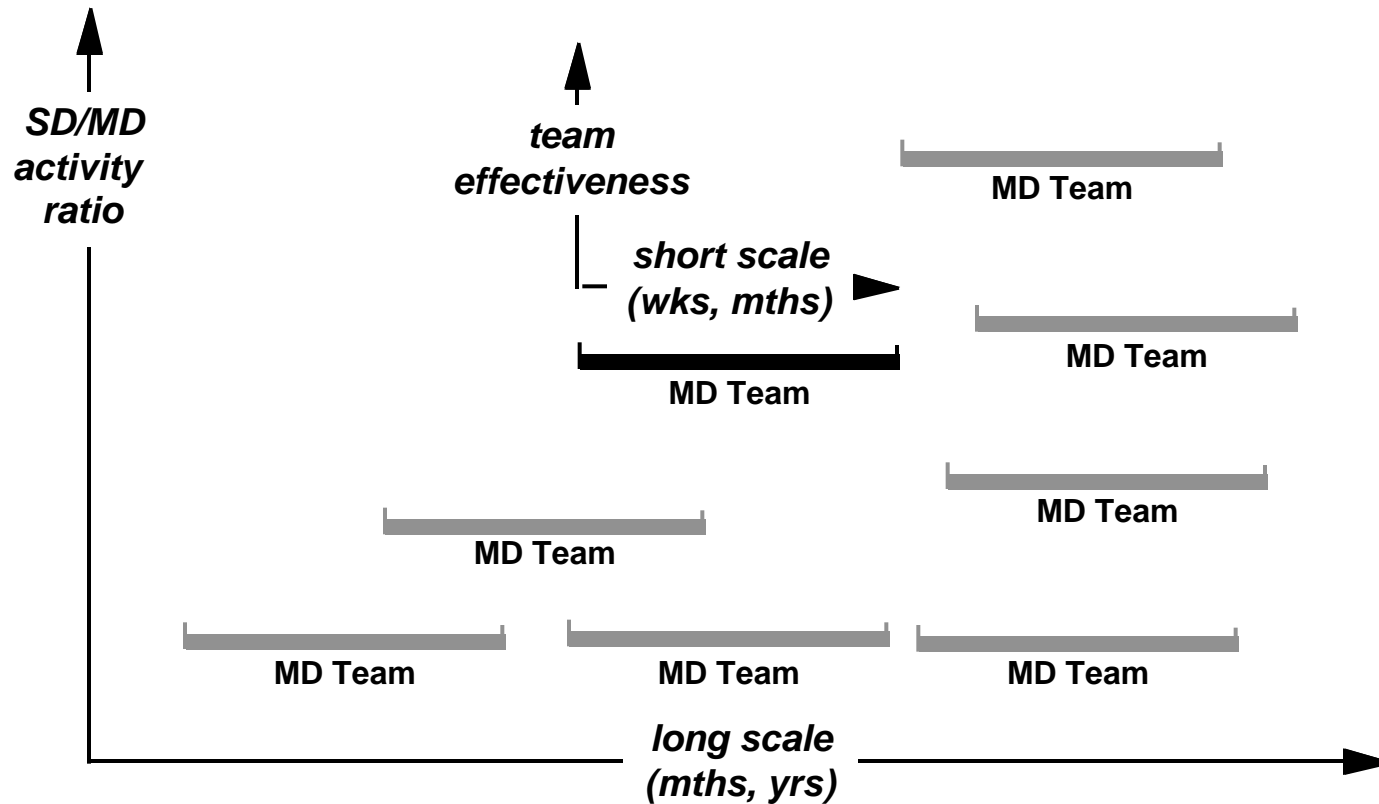**J. Sager, C. Sapp - Innovation Associates**

Objectives

- **Use 'System Thinking' techniques to assess the dynamics of the forces involved in the creation and maintenance of multidisciplinary teams at NASA/Langley**

- **Use the resulting assessments to identify high-leverage interventions**

Process

- **<u>Interview</u> selected participants on recently completed or on-going LaRC MD Teams:**
    - HSR/LCAP (Longitudinal Controls Alternative Project)
    - ANT (Airframe Noise Reduction Team
    - MDO-DPT (MDO-Detailed Planning Team)
- **<u>Combine</u> with team members experience in MD teaming and recently in ASPO project planning.**
- **<u>Separate</u> internal and external team dynamics**
- **<u>Identify</u> variables, causal relationships, external factors and mental models at play.**
- **<u>Recommend</u> interventions at the team member, team leader, line management, and project office level.**

External vs Internal Team Dynamics

SD/MD activity ratio

team effectiveness

short scale (wks, mths)

MD Team

MD Team

MD Team

MD Team

MD Team

MD Team

MD Team

MD Team

long scale (mths, yrs)

Outline

- **Objectives**
- **Process**
- **Observations/Assumptions**
- **Assessment**
  - **Sponsor Commitment**
  - **Technical Maturation and Cost/Benefit**
  - **Competence/Competency**
  - **Researcher Affinity**
  - **LaRC *Modus Operandi***
  - **Technical Maturation Gap**
- **Currently Operating Dynamics**
- **Intervention Summary**
  - **Individual Researcher**
  - **Line Organization (Branch, Division, Group)**
  - **Program Offices**

Observations

LaRC Resources are expended either in SD or MD work

- LaRC largely operates in a fixed resources environment, this translates in a fixed number of FTE's and/or $, for the sake of the discussion we'll think in terms of $.

- With those $, two kinds of activities can be carried out at LaRC: SD (<u>S</u>ingle<u>D</u>isciplinary) and MD (<u>M</u>ulti<u>D</u>isciplinary) activities.

- There has always been some level of MD activities at LaRC.

- There will always need to be some level of SD activities at LaRC.

> *There is a need to increase the volume of MD activities relative to the total volume of research activities, as a consequence this will result in reduced volume of SD activities.*

- Over time, there have been deliberate efforts to alter the SD/MD balance at LaRC (IRO, HiSAIR, MDO-RRC/DPT, MDOB...), they have met with varied success, as a consequence, different mental models are in place.

Observations
Many Organizations carry out MD work at LaRC

- **MDOB is the RTG organization tasked to carry out MDO methods development. It is also tasked to participate in MD application activities; it was not tasked nor staffed to carry out all MD applications, nor all related SD developments.**

- **MD work is carried out by other organizations within RTG or LaRC, but these organization do not have the charter to produce MD work.**

- **Since RTG and LaRC are mostly organized so that line organizations are aligned with SD competencies, many MD activities need to be carried out by horizontal cut teams.**

- **There is no infrastructure explicitly responsible for:**
  - **compiling a research portfolio with the proper balance between SD and MD**
  - **maintaining an MD core competency**
  - **grooming an MD workforce**
  - **retaining the experience gained in MD activities**

Observations

- **The balance between SD and MD activities (SD/MD balance) is now set by the program offices.**

- **Individual researchers as well as line management retain a significant indirect control on the SD/MD balance through their participation in the program office planning processes.**
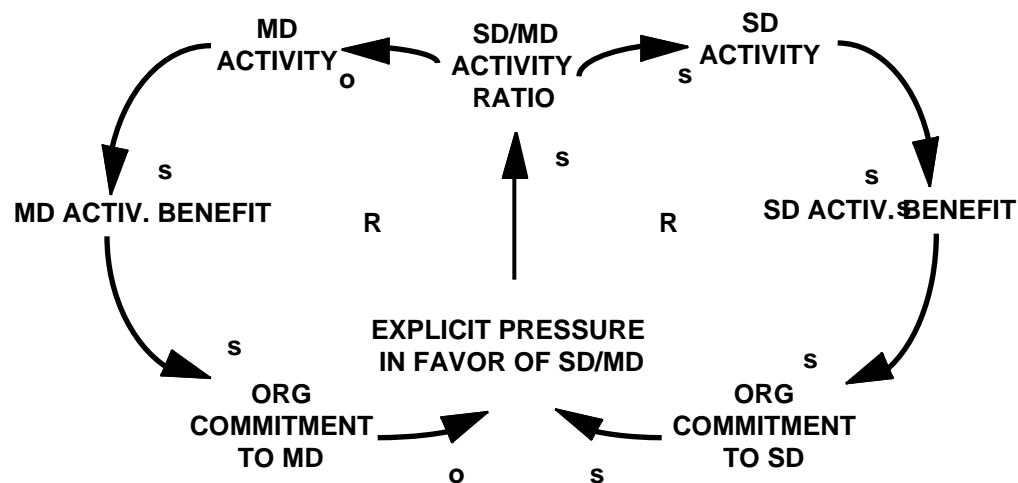
Assessment

Key Variable

- **The key variable in the loops is the ratio between resources applied to SD and resources applied to MD activities (SD/MD). It is presumed to be large now and to need to be reduced, reflecting the fact that more MD activities are carried out.**

- **Two kinds of pressures are present which set this ratio**
  - **an explicit pressure, based on tangible, quantifiable factors**
  - **an implicit pressure, based on less tangible factors**

Assessment
SD (MD) Activities Build-up Sponsor Commitment

___

mm: MD has not done anything for me

MD ACTIVITY

o

SD/MD ACTIVITY RATIO

s

SD ACTIVITY

s

s

MD ACTIV. BENEFIT

R

s

R

SD ACTIV. BENEFIT

s

s

EXPLICIT PRESSURE IN FAVOR OF SD/MD

s

ORG COMMITMENT TO MD

ORG COMMITMENT TO SD

o

s

Assessment
Key Archetype: Success to the successful*

- **Structure:**
  - pair of reinforcing loops; a virtuous circle, and a vicious circle

- **Story:**
  - two activities compete for a common limited resource
  - as activity A's success increases, more resources are allocated to it, less resources are available to B
  - with less resources, B's success decreases and less recources are allocated to B.
  - key to the dynamics: resource allocation decision rule

- **Interventions:**
  - + base resource allocation on potential and demonstrated success
  - + look for overarching goal for activities A and B
  - – break the resource link, if warranted
  - – look for additional resources, if possible

*System Thinking-Productive Conversation, Participant Manual,
Innovation Associates Inc.   1996, NASA Ver. 96.7

Assessment
SD (MD) Activities Build-up Sponsor Commitment

- **Key Structures:**
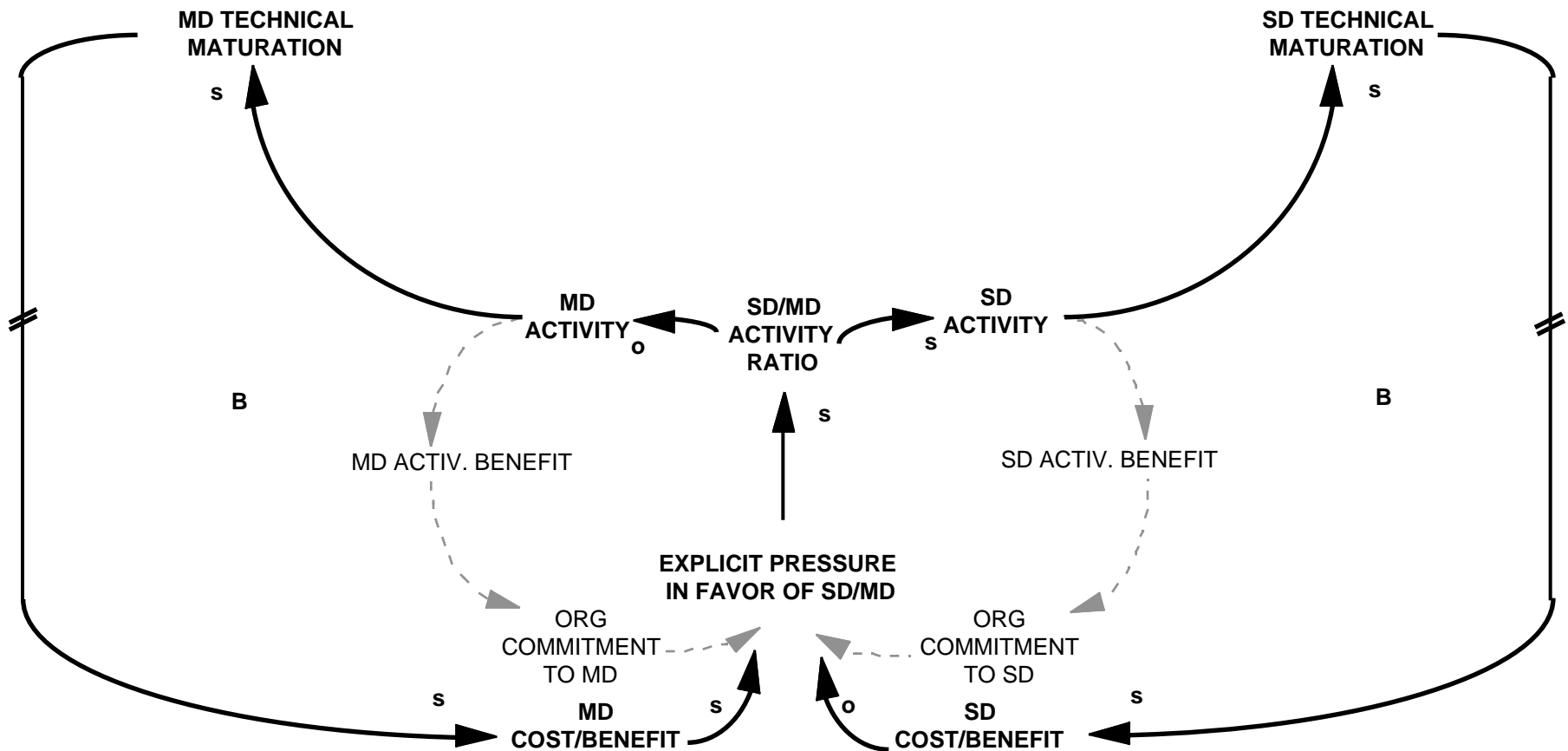 - **increasing SD (MD) activities results in SD (MD) benefits, improved sponsor commitment for SD (MD)**
  - **initial SD/MD ratio favors SD and results in more commitment in favor of SD**

- **Potential Interventions:**
  - **use reliable <u>system</u> <u>metrics</u> to set SD/MD balance**
  - **arbitrarily set the SD/MD balance, particularly at the outset**
  - **advertise benefits from MD activities**

Assessment
SD (MD) Activities Affect SD (MD) Technical Maturation, Cost/Benefit

***mm:* Everything is MD**   ***mm:* MD has not done anything for me**

MD TECHNICAL MATURATION

SD TECHNICAL MATURATION

s   s

MD ACTIVITY   SD/MD ACTIVITY RATIO   SD ACTIVITY
o   s

B   B

MD ACTIV. BENEFIT   SD ACTIV. BENEFIT

EXPLICIT PRESSURE IN FAVOR OF SD/MD

ORG COMMITMENT TO MD   ORG COMMITMENT TO SD

s   MD COST/BENEFIT   s   o   SD COST/BENEFIT   s

Assessment

SD (MD) Activities Affect SD (MD) Technical Maturation, Cost/Benefit

- **Key Structures:**
  - **increasing activities (SD or MD) increases technology maturation**
  - **eventually it decreases cost/benefit ratio, since diminishing returns are reached**

- **Potential Interventions:**
  - **develop system cost/benefit metrics**
  - **make calculation of benefit of MD over SD a requisite of MD activities**
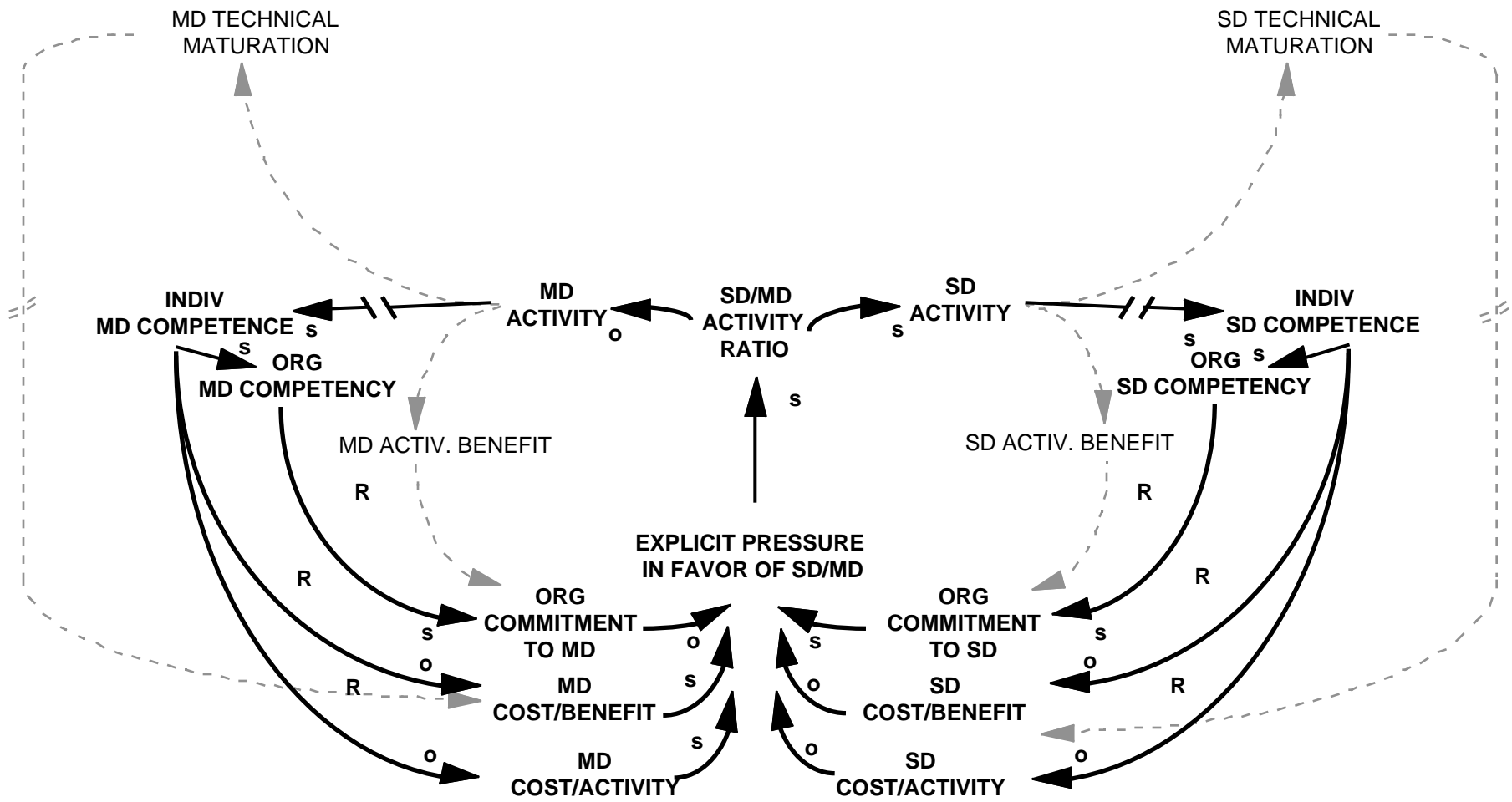 - **temporarily accept high cost/benefit MD activities to produce benefit to attract funding/participation**

Assessment
SD (MD) Experience Improves SD (MD) Competence/Competency

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mm: IMD work has better cost/benefit

mm: MD has not done anything for me

mm: Everything is MD

mm: IMD work is expensive

MD TECHNICAL MATURATION

SD TECHNICAL MATURATION

INDIV MD COMPETENCE

MD ACTIVITY

SD/MD ACTIVITY RATIO

SD ACTIVITY

INDIV SD COMPETENCE

ORG MD COMPETENCY

ORG SD COMPETENCY

MD ACTIV. BENEFIT

SD ACTIV. BENEFIT

EXPLICIT PRESSURE IN FAVOR OF SD/MD

ORG COMMITMENT TO MD

ORG COMMITMENT TO SD

MD COST/BENEFIT

SD COST/BENEFIT

MD COST/ACTIVITY

SD COST/ACTIVITY

MD Teams External Dynamics/ 15   10/22/97

Assessment
SD (MD) Experience Improves SD (MD) Competence/Competency

- **Key Structures:**
  - **Increased experience in SD (MD), increases indidual competence, therefore activity cost and cost/benefit.**
  - **If aligned, with core competency of organization, it is bound to increase organization commitment.**

- **Potential Interventions:**
  - **maintain an organization with an MD core competency**
  - **maintain an integration competency area in each SD organization**
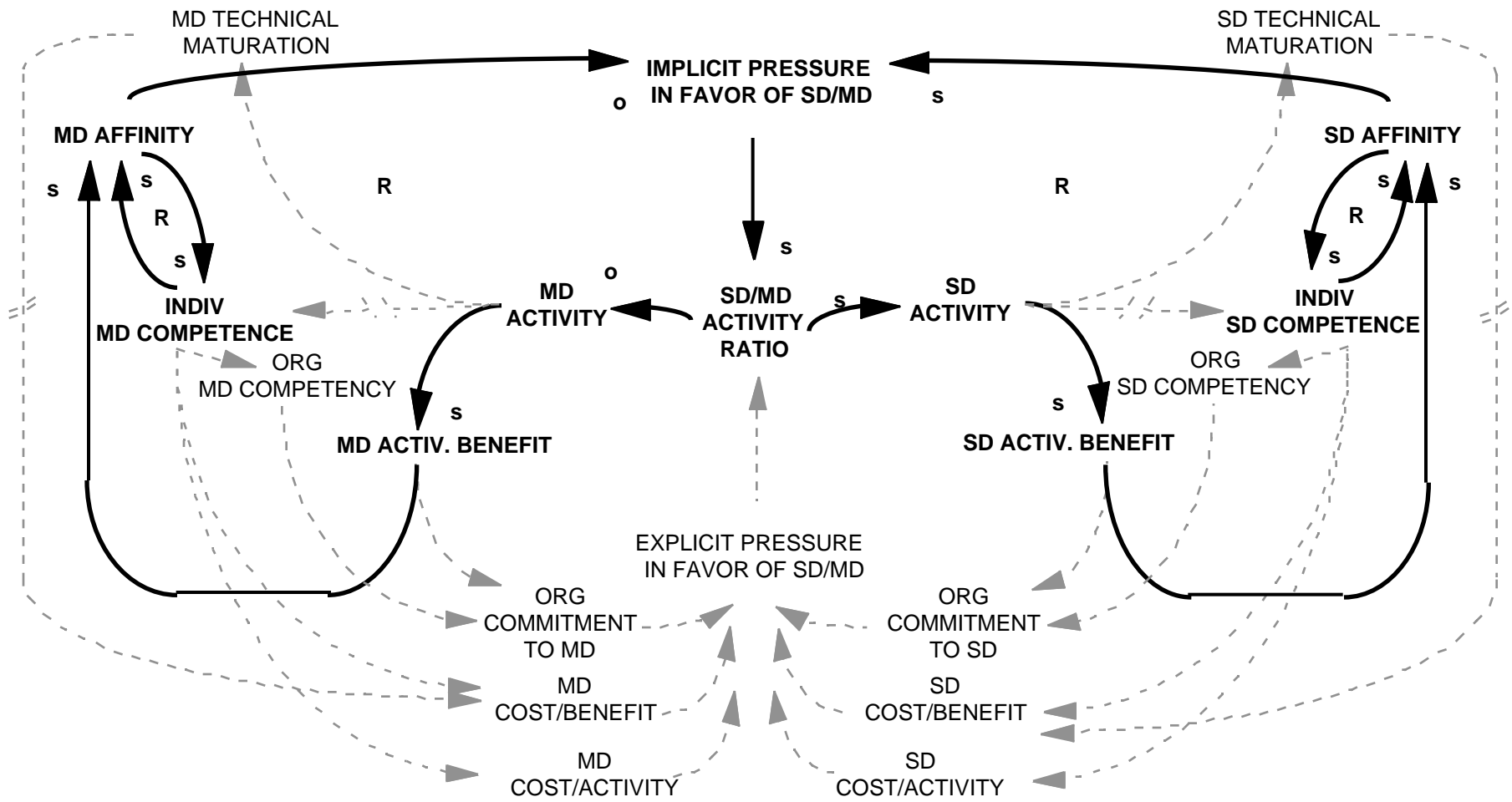 - **boost MD education, track and hire people with MD education/ experience**

Assessment

SD (MD) Experience Increases Affinity for SD (MD) Work

mm: IMD work is not recognized

*mm: IMD work is not rewarded*

mm: Iteam work is not rewarded

MD TECHNICAL MATURATION

SD TECHNICAL MATURATION

IMPLICIT PRESSURE IN FAVOR OF SD/MD

MD AFFINITY

SD AFFINITY

INDIV MD COMPETENCE

ORG MD COMPETENCY

MD ACTIVITY

SD/MD ACTIVITY RATIO

SD ACTIVITY

INDIV SD COMPETENCE

ORG SD COMPETENCY

MD ACTIV. BENEFIT

SD ACTIV. BENEFIT

EXPLICIT PRESSURE IN FAVOR OF SD/MD

ORG COMMITMENT TO MD

ORG COMMITMENT TO SD

MD COST/BENEFIT

SD COST/BENEFIT

MD COST/ACTIVITY

SD COST/ACTIVITY

MD Teams External Dynamics/ 17   10/22/97

Assessment

SD (MD) Experience Increases Affinity for SD (MD) Work

- **Key Structures:**

    - **SD (MD) benefit results in researcher affinity for SD (MD), as reinforced by personal satisfaction, rewards, and recognition**

    - **SD (MD) affinity, reinforces SD (MD) competency**

    - **SD (MD) affinity increases pressure for SD (MD)**

- **Potential Interventions:**

    - **explicitly recognize team work**

    - **explicitly recognize MD work**

    - **explicitly reward MD work**

Assessment

Long-term *Modus Operandi* Adds to Implicit SD/MD Pressure

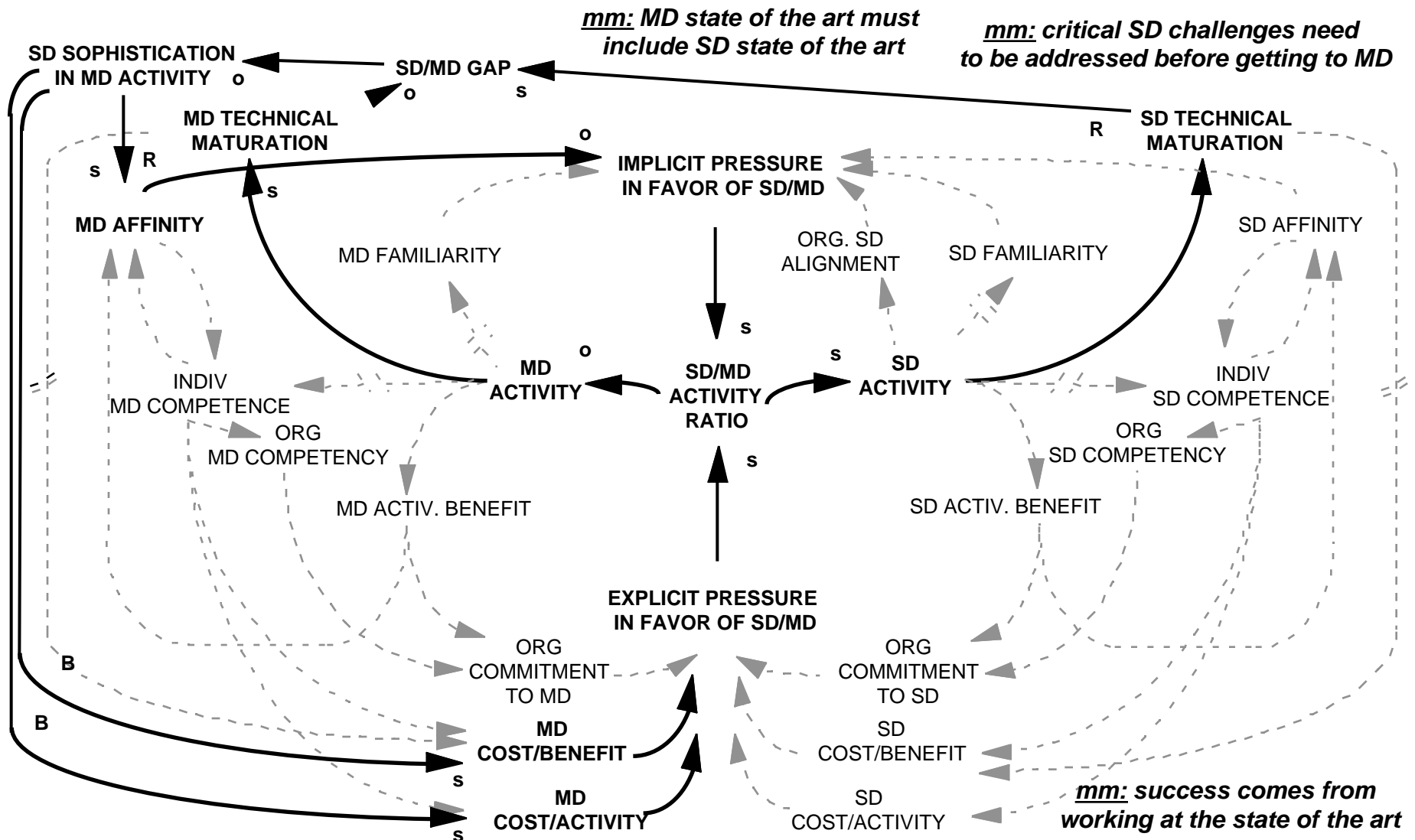

mm: I prefer working in my comfort zone
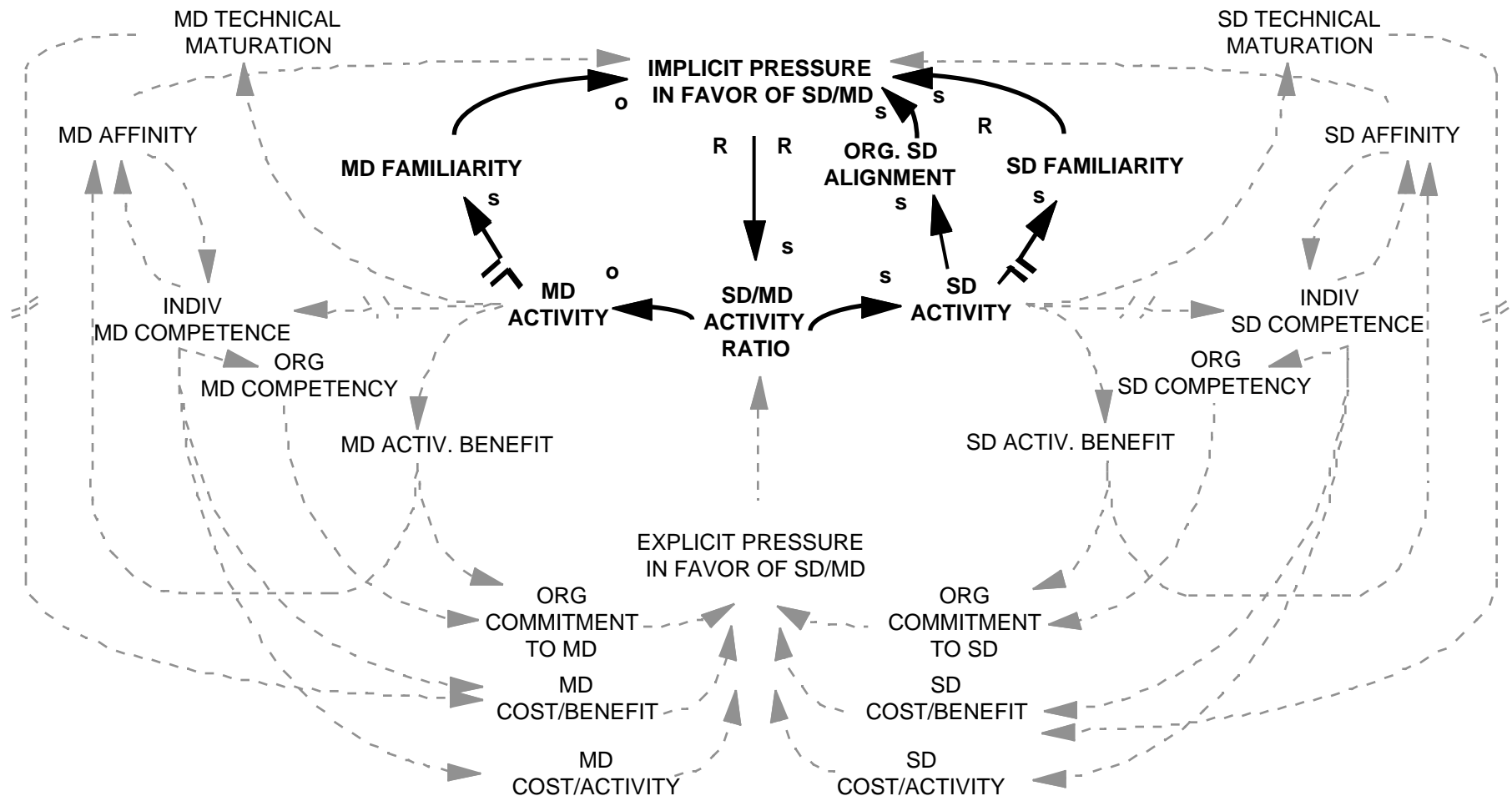
Assessment
Long-term *Modus Operandi* Adds to Implicit SD/MD Pressure

- **Key Structures:**
  - SD (MD) work reinforces individual familiarity with SD (MD) and therefore pressure in favor of SD (MD) work
  - LaRC heritage in SD work and its SD-aligned organizations maintain high SD/MD, therefore it reinforces line organization control and pressure for high SD/MD
  - a similar causal relationship does not exist on the MD side, as no organization is officially the keeper of MD applications

- **Potential Interventions:**
  - increase level of acceptable risk in SD, by conducting a higher proportion of fundamental work
  - maintain organization(s) that is (are) keeper of MD work
  - implement an effective matrix organization

Assessment

## SD (MD) Technical Maturation Affects SD/MD Gap

mm: MD state of the art must include SD state of the art

mm: critical SD challenges need to be addressed before getting to MD

SD SOPHISTICATION IN MD ACTIVITY

SD/MD GAP

MD TECHNICAL MATURATION

SD TECHNICAL MATURATION

IMPLICIT PRESSURE IN FAVOR OF SD/MD

MD AFFINITY

MD FAMILIARITY

ORG. SD ALIGNMENT

SD FAMILIARITY

SD AFFINITY

MD ACTIVITY

SD/MD ACTIVITY RATIO

SD ACTIVITY

INDIV MD COMPETENCE

INDIV SD COMPETENCE

ORG MD COMPETENCY

ORG SD COMPETENCY

MD ACTIV. BENEFIT

SD ACTIV. BENEFIT

EXPLICIT PRESSURE IN FAVOR OF SD/MD

ORG COMMITMENT TO MD

ORG COMMITMENT TO SD

MD COST/BENEFIT

SD COST/BENEFIT

MD COST/ACTIVITY

SD COST/ACTIVITY

mm: success comes from working at the state of the art

MD Teams External Dynamics/ 21   10/22/97

Assessment

SD (MD) Technical Maturation Affects SD/MD Gap

- **Key Structures:**

  - **SD (MD) activities increase SD (MD) technical maturation**

  - **SD (MD) technical maturation increases (decreases) SD/MD gap**

  - **Increasing SD/MD gap decreases SD sophistication in MD applications**

  - **SD researcher looses affinity for MD and increases SD/MD implicit pressure**

  - **but, MD application cost and cost/benefit improve, thereby reducing SD/MD explicit pressure**

- **Interventions:**

  - **balance SD sophistication in MD work**

  - **include capability to work MD problems as key component of SD work**

Summary
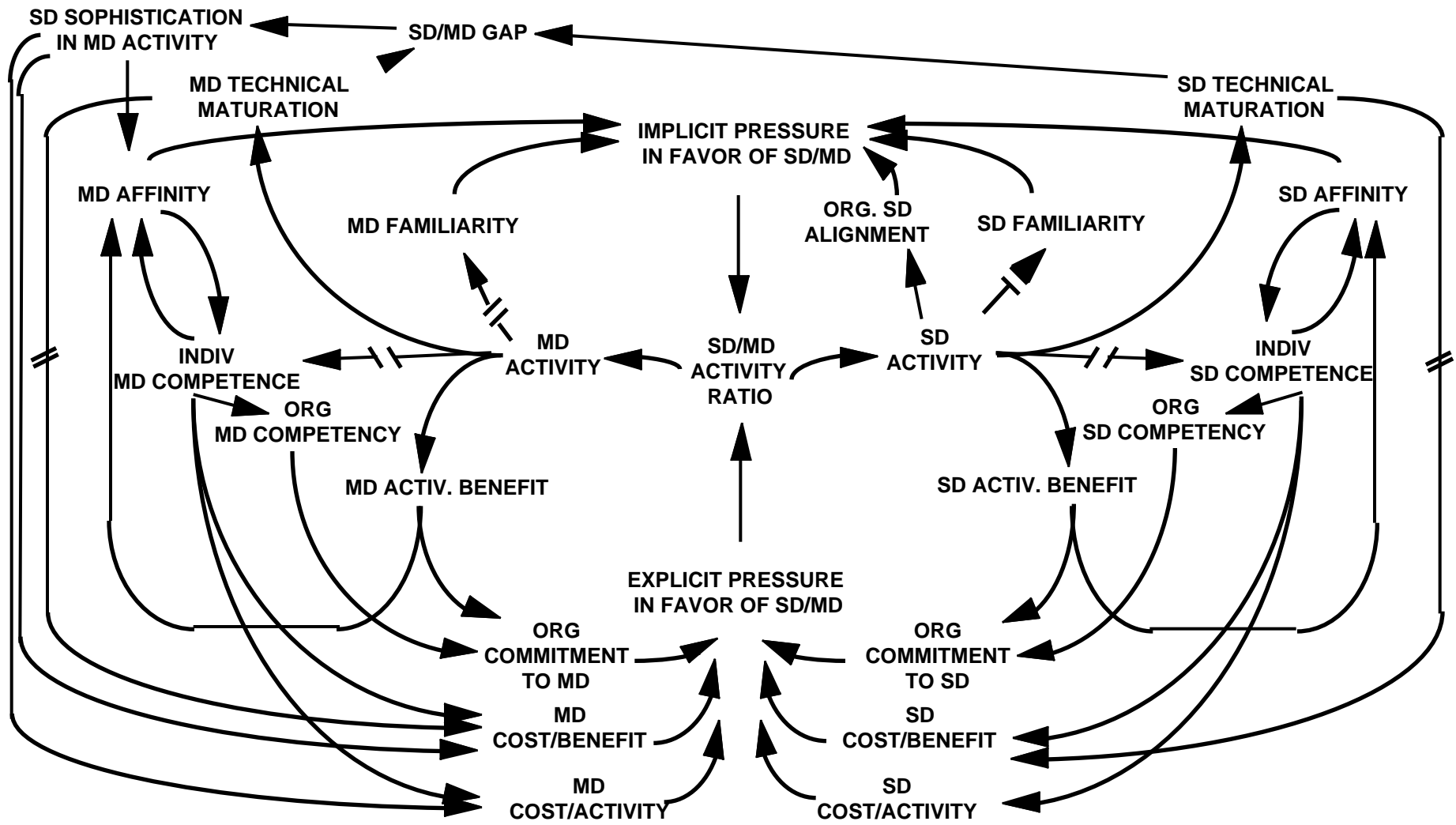
Summary

Comments

- **The diagram is mostly symmetric as it follows the success-to-the-successful archetype**
- **The only non symmetric elements are introduced by:**
  - **the lack of infrastructure responsible for MD activities**
  - **the tension existing between the SD state-of-the-art and the capacity for MD to accommodate it**
- **The lower part of the diagram deals with explicit decision making questions for which some metrics are available, the upper part deals with implicit issues, more difficult to quantify**
- **Most loops are reinforcing, therefore, with the right interventions, they can be set in motion and become virtuous loops driving the process towards a more favorable SD/MD ratio**

Operating Loops at LaRC
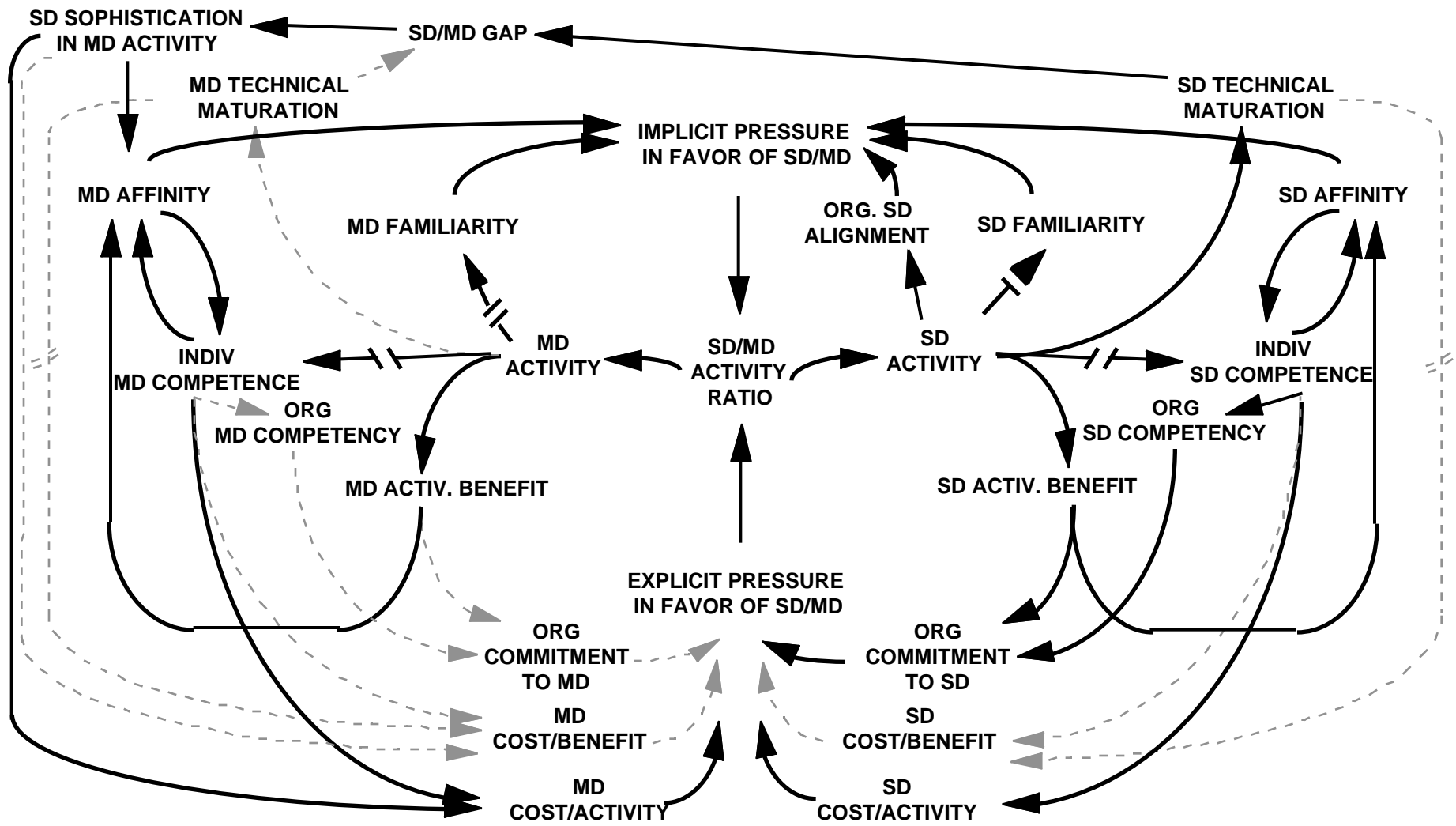
Operating Loops at LaRC

Comments

- **Cost benefit analyses on a system metric basis are difficult to make and to factor in decisions needed to balance the R&D portfolio; this affects both the SD and MD sides**

- **Aside from MDOB, there is no line organization that is the keeper of MD applications,**
  - **diagram asymmetry is accentuated**
  - **championing of MD work remains at the individual level**

Intervention Summary

Individual Researcher

- **In SD work**
  - **include capability to work MD problems as component of SD work**
  - **increase acceptable risk level, conduct more fundamental SD work**
  - **balance SD sophistication in MD work**

- **In MD work**
  - **advertise MD benefits**
  - **develop system cost/benefit metrics**
  - **balance SD sophistication in MD work**

Intervention Summary

Line Organization

- **Personnel Issues**
  - explicitly recognize MD work
  - explicitly reward team work
  - explicitly reward MD work
  - boost MD education, track/hire people with MD education/experience

- **Core Competency Issues**
  - maintain an infrastructure to with an MD core competency
  - maintain an integration competency area within each SD organization

Intervention Summary

Program Offices

- **Research Package Content**
  - make calculation of benefit of MD over SD a requisite of MD activities
  - sponsor more fundamental SD work
  - require capability to work MD problems as a component of SD work

- **Balanced Portfolio**
  - use reliable system metrics to set SD/MD balance
  - arbitrarily set the SD/MD balance
  - temporarily accept high cost/benefit MD activities to produce benefit to attract funding/participation